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ABSTRACT

The United States of America is a society dependent upon science and technology. This will be even more evident in the 21st century, when many jobs will exist in fields not yet developed. Decisions relating to yet unknown data will need to be made. The individual will need to be scientifically and technologically literate to be able to relate to the home, the workplace, and the global community. To provide quality education in preparation for the future, the Ohio Department of Education continues to believe that science education is an important priority for our students. A quality science program that develops in students the skills and tools to meet the challenges of the future must be provided. This publication provides school district personnel with current information, creative ideas, and suggested procedures for planning and implementing improved science education programs. The document discusses problems and issues in science education; scientific literacy; effective science program characteristics, design, development, and implementation; and science program goals. A list of scientific thinking and process skills, and a science program self-appraisal instrument are appended. (CW)

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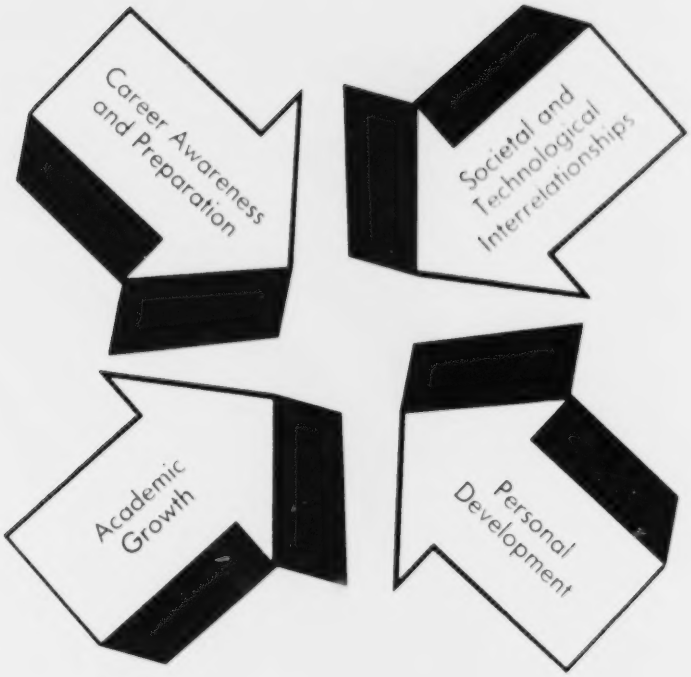

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IN SCIENCE EDUCATION

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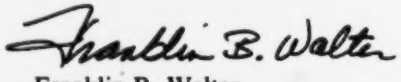
Foreword

The United States of America is a society dependent upon science and technology. We shall become even more aware of this fact in the twenty-first century, when many jobs will exist in fields not yet developed. Decisions relating to yet unknown data will need to be made. The individual will need to be scientifically and technologically literate to be able to relate to the home, the workplace, and the global community.

To provide quality education in preparation for the future, the Ohio Department of Education continues to believe that science education is an important priority for our students. We must provide a quality science program that develops in students the skills and tools to proactively meet the challenges of the future.

This publication provides school district personnel with current information, creative ideas, and suggested procedures for planning and implementing improved science education programs. This task is critical. We must prepare Ohio students to direct their futures in a highly scientific and technological society.



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Introduction

The curriculum in Ohio schools mandates science instruction. The science instruction that all Ohio students receive represents an enormous commitment of time and resources. Although the commitment to science education is strong, evidence suggests a need to examine how that commitment is fulfilled. An examination of science education begins with a basic definition of science.

What is science?

> Science is a human activity through which problems and questions dealing with natural phenomena can be identified and defined, and solutions proposed and tested. In this process, data are collected and analyzed, and available knowledge is applied to explaining the results. Through this activity, investigators add to the store of knowledge, thereby helping people better understand their surroundings. Applications of this knowledge also may bring about changes in society and the cultural order and may have a direct bearing on the quality of life.[1]

Science is a human enterprise that is attitudes, processes, and products. It is the process of developing attitudes and seeking explanations and understandings about the natural world. The product of that process is knowledge. Although the processes of science should be free of politics, the product — the knowledge obtained — becomes embroiled in power struggles for control.

What is the value of science education?

Through studying science students learn scientific knowledge and skills that are useful to them throughout their lives. Science develops attitudes, such as a predisposition toward curiosity and open-mindedness, which individuals then use in thinking critically, solving problems, developing sensitivity to environmental concerns, and taking responsibility for one's actions. Science education helps students understand and relate to the major decisions involved in living in a global society. It provides them with the tools to interpret and discover new information and scientific knowledge that will help them understand today's problems and contribute to their solutions.

As adults, today's students will face critical decisions about issues such as environmental pollution, use of atomic power, prevention of worldwide hunger, and exploration of space. Although there must be a cadre of skilled professionals to deal with developing and applying scientific knowledge, there must also be a broad-based, scientifically literate citizenry that can respond to the scientific implications of social and technological issues.

Solving tomorrow's problems requires understanding of the underlying scientific principles. A scientifically literate citizenry is essential for responding to social and technological issues and problems. Science is a vital and fundamental subject for all.

[1] Wisconsin Department of Education, *A Guide to Curriculm Planning in Science.* (Madison, Wisconsin: Bulletin 6270, 1986, p.8.)

What is the role of educators?

Educators, regardless of discipline or grade level, are in a position to help students become aware of the importance of science and to provide them with the skills and understanding to interpret phenomena scientifically. Educators must create a dynamic program for science education. They must encourage students to develop the attitudes and skills necessary for problem-solving and critical-thinking as well as to learn concepts, principles, and facts. They should teach their students to explore their world rather than to accept the secondhand experience provided by a textbook.

The responsibility of science education falls jointly on administrators, curriculum planners, and teachers. All educators must provide the leadership, educational climate, instructional resources, and inservice opportunities to develop and maintain an effective science program. They must accept responsibility for continually improving the science program.

Summary

This document addresses the issue of how to move science education beyond instruction in facts to the application of concepts. Through learning how to apply concepts, students as citizens will be better equipped to function productively in society and to contribute to its advancement. By identifying the major issues and future directions of science education, this manual outlines the process of improving science education in Ohio schools to achieve "new dimensions in science education."

Improvement can be expected only after sustained effort. This document contains a ten-step plan for consideration by school administrators, curriculum planners, and teachers involved in long-range planning. The need to improve science education is critical.

2

PROBLEMS AND ISSUES SCIENCE EDUCATORS FACE

Results of recent studies of science education in this country and abroad have caused concern regarding the effectiveness of United States' science programs. Science educators need to focus on improving curricula and teaching methods.

Problems of Science Programs

In 1977 and 1978, three important research efforts attempted to document the status of science education in the United States. The first study[2] summarized the literature from 1957-1975. It surveyed information on school practices, instructional materials, teacher education, administrative financial controls, and needs in K-12 science. The second study[3] surveyed educators nationwide, including teachers, administrators, supervisors, and other school personnel, about curricula, course offerings, teaching methods, enrollments, individualized materials, teaching assignments, support services, and demographic information. The third study[4] which consisted of 11 case studies of schools chosen to represent different types of communities, included extended on-site vists and in-depth analyses of the case study reports.

As summarized in *Research Within Reach*,[5] these research studies seem to identify the following problems.

- *The textbook is the curriculum.* These studies reveal that 90 percent of all science teachers in the U.S. use a textbook 95 percent of the time. The textbook determines the course content, mode of instruction, and evaluation.
- *Goals are narrowly defined.* A principal justification for school science at every level is the preparation it provides for the next academic level. The goals of science instruction are often limited to specific knowledge and processes.
- *The lecture is the major form of instruction, with laboratories for verification.* Most science courses fail to include any experimentation that allows a student to identify and define a problem, propose procedures, collect and interpret results, or make decisions.
- *Success is evaluated in traditional ways.* Evaluation of success places importance only on the dimension of knowledge. Science knowledge is often limited to definitions, vocabulary, terms, and laws.
- *Science appears removed from the world outside the classroom.* We have turned the classroom into the room in which science occurs. Science appears to have little relevance to the rest of the students' lives.
- *A shortage of science teachers has led to the widespread use of underqualified teachers.* Teachers are teaching subjects outside their major field of study.
- *The dated curriculum fails to provide for the broad variety and needs of students.* Our current science courses often focus on science and frequently omit practical applications, technology, and the relevancy of science to society's problems. We are not preparing individuals to enter occupations that require general technological knowledge.

[2] S.L. Helgeson, P.E. Blosser, and R.W. Howe, *The Status of Pre-College Science, Mathematics, and Social Science Education: 1955-1975.* (The Center for Science and Mathematics Education, The Ohio State University, Columbus, Ohio 1977).

[3] I.R. Weiss, *Report of the 1977 National Survey of Science, Mathematics, and Social Studies Education.* (Center for Educational Research and Evaluation, Research Triangle Park, N.C., 1978).

[4] R.E. Stake and J. Easley, *Case Studies in Science Education, Volumes I and II,* (Center for Instructional Research and Curriculum Evaluation, University of Illinois, Urbana-Champaign, 1978).

[5] D. Holdzkom and Pamela B. Lutz, ed., *Research Within Reach,* (Research and Development Interpretation Service, Charleston, West Virginia).

- *Current science instruction fails to use new information about how people learn science.* Information on cognitive psychology should be used in the classroom to help science teachers approach instruction that adds to the development of the individual. For example, teachers should be able to identify misconceptions that students hold related to the science concepts being taught. They will need to devise strategies to perceive these misconceptions and to replace them with scientifically correct concepts.

- *Supplies, equipment, and other resource materials are often limited and obsolete in science classrooms and laboratories.*

- *Science instruction in the elementary school receives inadequate attention.*

In another study prepared by participants in *Project Synthesis*[6] some additional observations were made.

- In comparison to mathematics, language arts, and social studies, science education has a relatively low status and receives less general support.

- Academic preparation has been the dominant component of science education, particularly in the most widely used textbooks. Other goals, such as relating science to everyday life, considering scientific careers, and becoming literate in scientific decision-making practices, were mostly overlooked.

Achievement Test Scores

Data obtained from numerous national and international studies provide evidence that students are not adequately prepared in science. American students do not score well on achievement tests in science when compared to students in other countries.

Although test scores have increased some in recent years, the gains have not been large. Scores for able students planning science and mathematics careers have remained stable or shown slight gains. Achievement scores for black, minority, and handicapped students have shown improvement, but still lag behind. By the time females graduate from high school, their scores are lower than males. The lowest achievement scores are found in the areas of physical science, problem-solving, and applications. Some tests have shown recent declines in earth science and integrated science topics.

One must keep in mind, however, that few of these tests examine the broad range of science education's goals. Most of the tests are multiple choice and focus primarily on recall of specific information. They do not test for process skills, problem-solving, or critical-thinking behaviors.

What can be done?

Although there is substantial debate regarding the desired curriculum for science education, consensus is that the science curriculum needs to be modified to:

- Include more emphasis on attitudes, problem-solving, critical-thinking, decision-making, applications, technology, societal issues, and the physical sciences

[6] N.C. Harms and J. Kahle, *The Status and Needs of Pre-College Science Education: Report of Project Synthesis* (Final Report to NSF for Grant, SED 77-19001, Washington, D.C., 1978).

- Reflect current understanding of the nature of the learner and of learning
- Increase the amount of time available for science instruction
- Provide appropriate experiences and courses for all students at all grade levels
- Increase the use of appropriate technology
- Use achievement measures that match the science curriculum more closely

Summary

Research suggests that schools may be fulfilling the mechanics of science requirements, but may benefit from modifications in their curriculum to fully develop their students' potential in science. Even students who are considered "academically" successful may not believe science is a useful, practical subject. Unfortunately, even achievement scores suggest that academic competence is not what it should be. The challenge facing the Ohio science educator who wants to remedy these deficiencies is to integrate improvements into a comprehensive science program.

WHAT IT MEANS TO BE A SCIENTIFICALLY LITERATE PERSON

The evidence supports the need for new approaches to science education. The place to begin the development is with the selection of a new goal for science education, which is to develop a scientifically literate person.

Although the concept of scientific literacy was developed in the 1950's, it remains a universal, timeless goal for science education. In an ideal world, an individuals's progress toward scientific literacy continues throughout life, beginning with a firm foundation in elementary school.

A National Science Teachers Association (NSTA) position statement provides insight into science education for the 1980's.

> The goal of science education during the 1980's is to develop scientifically literate individuals who understand how science, technology, and society influence one another and who are able to use this knowledge in their everyday decision making. The scientifically literate person has a substantial knowledge of facts, concepts, conceptual networks, and process skills that enable the individual to continue to learn and think logically. This individual both appreciates the value of science and technology in society and understands their limitations.
>
> The attributes listed below help to describe a scientifically literate person. Each attribute should be thought of as describing a continuum along which the individual may progress. The progress of the individual's science education should be equated with progress along this continuum.

The scientifically and technologically literate person

- Uses science concepts, process skills, and values in making responsible everyday decisions
- Understands how society influences science and technology as well as how science and technology influence society
- Understands that society controls science and technology through the allocation of resources
- Recognizes the limitations as well as the usefulness of science and technology in advancing human welfare
- Knows the major concerns, hypotheses, and theories of science and is able to use them
- Appreciates science and technology for the intellectual stimulus they provide
- Understands that the generation of scientific knowledge depends upon the inquiry process and upon conceptual theories
- Distinguishes between scientific evidence and personal opinion
- Recognizes the origin of science and understands that scientific knowledge is tentative and subject to changes as evidence accumulates
- Understands the applications of technology and the decisions entailed in the use of technology

- Has sufficient knowledge and experience to appreciate the worthiness of research and technological development
- Has a richer and more exciting view of the world as a result of science education
- Knows reliable sources of scientific and technological information and uses these sources in the process of decision making[7]

These are the attributes that make up the scientifically literate individual. The next step is identifying a curriculum, which must create the educational climate for nurturing the scientifically literate individual.

Project Synthesis Provides the Basis for a New Curriculum

Considered a significant document in science education literature, *Project Synthesis*[8] has been used to initiate changes in science curricula across the country. These changes would hopefully result in students' becoming scientifically and technologically literate and fulfilling the goals outlined in the previously described NSTA position paper. For this reason, the Inservice Education Science Advisory Council has chosen *Project Synthesis*[9] as the model for an effective curriculum in *New Dimensions in Science Education*.

Project Synthesis originated in 1978 when the National Science Foundation (NSF) awarded a major research contract for the purpose of synthesizing and interpreting more than two thousand pages of information from three NSF status studies and National Assessment of Educational Progress (NAEP) reports. A team of twenty-three science educators under the direction of Norris Harms of the University of Colorado participated in this research effort, called *Project Synthesis*.

Project Synthesis documented the fact that science education has traditionally stressed academic goals and neglected other areas that contribute to an individual's development.

To remedy these deficiencies, *Project Synthesis* recommends a holistic approach that adds new goals to the traditional science curriculum. The new goals provide a wider developmental focus to supplement traditional academic goals. They require more than mastering facts and independent data for success. Emphasis is placed on the skills of problem-solving and decision-making based on scientific principles and processes.

The four goal clusters of *Project Synthesis* are

- ***Personal development*** This cluster involves skills and knowledge that students will find useful in dealing with their own lives.
- ***Societal and technological interrelationships*** This component prepares the individual for dealing with science-related societal issues.
- ***Academic growth*** Students gain the knowledge and skills to progress in an academic environment.
- ***Career awareness*** This approach provides students with information about various scientific and technologically related careers![10]

[7] "Science-Technology-Society: Science Education for the 1980's," National Science Teachers Association, Washington D.C., (1983).

[8] Harms and Kahle, op.cit.

[9] Harms and Kahle, op.cit.

[10] Harms and Kahle, op.cit.

Incorporating these goal clusters into a science curriculum will do more than prepare students academically for advanced studies in science. Students will learn to (1) use science in their daily lives, (2) engage in intelligent decision making relative to science and societal issues, and (3) make decisions about selecting (or not selecting) scientific or technological careers![11]

Summary

Adopting these goal clusters will necessitate changes in planning science programs. The traditional curriculum often overemphasizes academic growth at the expense of the other goal clusters — personal development, societal and technological interrelationships, and career awareness. This results in an overemphasis on textbooks and on courses that are too narrowly designed.

New Dimensions in Science Education's intent is to encourage the development of new, effective science curricula that present students with a continuum of activities that emphasize all four goal clusters. The remainder of this document addresses the development of curricula based on *Project Synthesis.*

[11] Harms and Kahle, op.cit.

CHARACTERISTICS OF AN EFFECTIVE SCIENCE PROGRAM

Development of an effective science program must include a comprehensive consideration of every aspect of the school program that directly influences the quality of classroom instruction. Such development requires examination of learners' unique characteristics and needs and of teachers and administrators' role in accomplishing the program goals. Curriculum development, selection of instructional materials, and the nature of instructional practices in classrooms must receive serious and thorough consideration. Even an excellent program will succeed only when its administration supports staff development and provides adequate instructional facilities and resource materials. Instructional leadership must be cultivated and nurtured to ensure an ongoing, effective science program. Effective programs should be based on strong framework and be flexible enough to adapt to the latest learning theories.

Designed to be compatible with students' needs and characteristics, the program should

- Maintain, expand, and use students' natural curosity
- Involve students in exploring and expanding their environment
- Focus on topics of interest to students
- Develop new ways of viewing materials
- Be relevant to learners' lives and accessible to all students
- Match students' developmental phases and interests
- Provide instructional experiences about scientific concepts and processes that are compatible with students' abilities and are organized according to grade-level blocks
- Utilize a demographic evaluation to develop the science program
- Identify learners' special needs
- Utilize community resources

Learner Characteristics

Learners in an effective program will fit into the following characteristic groupings (adapted from the California Science Framework Addendum [1984]).

Learning in kindergarten through grade 3

These grade levels respond to statements of knowledge that help one OBSERVE, COMMUNICATE, COMPARE, and ORGANIZE material objectives in the universe.

This grouping is largely organizational in character and correlates well with two of Piaget's stages of cognitive development; the preconceptual state (two through four years) and the state of intuitive thinking (four through seven years). To a great extent, the knowledge statements in this grouping represent concepts that may be symbolized by single words (e.g., bird, solid, and star). The key processes that a learner must concretely experience to understand and use this knowledge include OBSERVING, COMMUNICATING, COMPARING, and ORGANIZING.

Learning in grades 4 and 5

These grades respond to statments of knowledge that help one understand the interactions and interdependence of systems of objects.

This grouping is largely relational in character and correlates well with Piaget's stage of concrete operations (seven through eleven years) because such statements require the coordination of more than one thought. To a great extent, the knowledge statements in this grouping represent the principles, generalizations, and laws. The key processes that a learner must experience to understand and use this knowledge include OBSERVING, COMMUNICATING, COMPARING, ORGANIZING, and RELATING.

Learning in grades 6 through 8

These grades respond to statements of knowledge that help one explain phenomena through perceived changes in objects.

The grouping is largely theoretical in character and correlates with Piaget's period of formal operations (eleven years and older). To a great extent, the knowledge statements in this grouping represent ideas that are not directly observable. The processes a learner must experience to understand and use this knowledge include OBSERVING, COMMUNICATING, COMPARING, ORGANIZING, RELATING, and INFERRING.

Learning in grades 9 through 12

These grades respond to statements of knowledge that pertain to ways of using information primarily to obtain further knowledge.

This grouping is an application in character, and it correlates with Piaget's period of formal operations (eleven years and older). To a great extent, the knowledge statements in this grouping represent inventions and technology. Many statements may be rephrased to suggest usage. The key processes that learners need to understand and use this knowledge include OBSERVING, COMMUNICATING, COMPARING, ORGANIZING, RELATING, INFERRING, and APPLYING.

Teacher Responsibilities

The teachers of effective programs have a clear understanding of science education goals.

They know that their responsibilities are to

- Be content-competent
- Contribute to curriculum development
- Provide various experiences with content, processes, and other dimensions of science, including the physical, biological, and earth sciences
- Cover topics pertaining to technology and current community and societal problems that have scientific implications

- Encourage students to be problem-solvers and users of their experiences with science
- Share their expertise in curriculum development and implementation with other professionals
- Display enthusiasm and a positive attitude about teaching science
- Participate actively in inservice activities, including conferences and workshops that provide professional growth
- Be involved in professional organizations

Staff Development

Staff development for science educators should be an ongoing process in a school district. The school district should

- Establish a library of science education materials for the teaching staff. These should include national science education research journals, newsletters and journals of the state science teachers' associations, and other science education reference materials to serve as sources for new ideas.
- Permit release time so teachers can participate in science education programs designed to improve science teaching.
- Design inservice programs that offer teachers specific skills, techniques, and materials that can immediately be useful to them in their science classes.
- Enable teachers to learn new science teaching techniques, try newly-adopted science curriculum materials, and participate in activities similar to those their pupils will be doing prior to the time they are expected to use them in their classrooms.
- Encourage and support teachers' participation in professional activities, including conferences and conventions that provide inservice opportunities.
- Establish inservice partnerships with local colleges and universities.

Program Administration

In an effective science program, the administrators should play an active role and should

- Be aware of current developments in science curricula
- Assume a leadership role in deciding on planning programs, selecting instructional materials, and evaluating results
- Establish science as a district priority, emphasizing its importance to society
- Support science education with an adequate annual budget that allocates funds to purchase sufficient materials for all students to experience hands-on activities

- Provide direct communication with all personnel—classroom teachers, resource teachers, department heads, building administrators, supervisors, and central office personnel

- Promote curriculum development from within the staff by providing release time or supplemental pay and recognition

Curriculum

The effective science curriculum should

- Be a comprehensive K-12 program with established goals and objectives that include PERSONAL DEVELOPMENT, SOCIETAL AND TECHNOLOGICAL INTERRELATIONSHIPS, ACADEMIC GROWTH, and CAREER AWARENESS

- Include opportunity for developing a positive attitude toward science

- Include goals that provide all students, including handicapped, minorities, and women, with opportunities to succeed and find application for their learning

- Be comprehensive in its scope and encompass kindergartners through twelfth graders

- Incorporate an activity approach to science, with abundant, concrete, hands-on laboratory experiences through which students learn the content and processes of science throughout the program

- Review the social and historical context of scientific discoveries

- Promote environmental education by providing educational experiences outside the classroom such as visits to nature centers, museums, zoos, airports, factories, and other settings where scientific subjects can be observed or scientific knowledge put to practical use

- Foster the development of problem-solving, decision-making, and creative and critical-thinking skills

- Emphasize the integration of maior concepts and principles as opposed to the learning of individual facts and less significant concepts and principles

- Develop content and activities that emphasize a wide range of student abilities and interests

- Include an evaluation that is congruent with the program's goals and objectives

Instructional Materials and Resources

Students enrolled in an effective program should be exposed to a wide variety of instructional materials, resources, and instructional methods. Examples of these are

- Community resources
- Libraries and other research facilities
- Hands-on activities
- Laboratory experiences
- Textbooks and other instructional materials

There is a need to examine and choose instructional materials and resources that meet the local goals and objectives designed prior to their selection. The Inservice Education Science Advisory Council has designed an *Evaluative Tool for Science Instructional (Print) Materials*[12] This instrument is a suggested mode for determining whether instructional materials under consideration are appropriate.

School Facilities

Classroom facilities are an essential element in achieving the program's goals and objectives. They should

- Offer various interactive modes to stimulate curosity and invite investigation
- Allow for flexible seating and the necessary resources, such as water, ventilation, and electrical outlets.
- Provide adequate storage facilities
- Provide adequate safety materials
- Provide adequate materials for the number of students being instructed

Summary

Science is an integral part of the school curriculum. The carefully planned and articulated science program provides daily opportunities for developing and applying science concepts, utilizing science process and inquiry skills, and developing a positive attitude toward science. Through hands-on experiences, students explore and investigate their world with readily available instructional materials. The science program gives students an understanding of and an appreciation for their world.

[12] *Evaluative Tool for Science Instructional (Print) Materials*, The Ohio Department of Education, (Columbus, Ohio: 1986).

HOW TO DESIGN AND IMPLEMENT CHANGES IN THE SCIENCE PROGRAM

Improving a science program requires broad-based participation and commitment. To guide the improvement effort, this chapter provides a ten-step plan in which the school district evaluates its program for strengths and weaknesses and develops a format for improvement. From that information, the school district then begins to design and implement changes.

Preliminary Planning

Before embarking on the improvement process, the school district personnel should accomplish three tasks. Successful completion of these tasks may make the difference between the improvement effort's success or failure.

- *Commitment* The first action in the process is to elicit commitment to the effort. Participants should be willing to commit time to the effort and should philosophically support the need to improve the curriculum.

- *School District Science Improvement Committee* Organizing a science education improvement committee is a critical step. The members should represent a variety of constituencies and should be carefully chosen from interested community members, students, teachers, administrators, and others. Members with cooperative and consensus-building skills are key to the committee's success.

- *Plan and Time Line* The committee should develop a plan and detailed time line for the improvement process. This will establish overall organization.

Having made a commitment to these three tasks, the School District Science Improvement Committee may follow the ten-step, two-year plan presented on page 18.

Timeline to an Improved Science Education Program

Steps	Time In Two-Year Plan
1. Review state standards, relevant literature, current research, and effective programs to establish evaluation criteria.	3 months
2. Review all aspects of present program in relation to results in Step 1. See Appendix B; *Science Program Self-Appraisal*, Ohio Department of Education, 1986.	3 months
3. Note and describe points of discrepancy between evaluation criteria (Step 1) and the district's present program (Step 2) to determine changes desired.	3 months
4. Write a detailed plan addressing action and resources (personnel and financial) needed to accomplish desired changes.	2 months
5. Write a K-12 course of study that includes science philosophy, goals, subject objectives, scope and sequence, evaluation procedures, and board approval statement.	4 months
6. Write a K-12 curriculum guide that includes learning activities, teaching strategies, required materials, and equipment.	6 months
7. Select materials and equipment.	2 months
	23 months
8. Conduct administrator and teacher inservice training.	Continuous
9. Monitor progress to evaluate whether or not changes are taking place by formulating an evaluation plan.	Continuous
10. Write report on successes, failures, and recommendations for future improvements.	1 month

Descriptive - Ten Steps to an Improved Science Education Program

These ten steps are suggested as a model, which can be modified according to the district's requirements.

1. Review state standards, relevant literature, current research, and effective programs to establish evaluation criteria.

   - Review state and national literature, research, and effective programs.
   - Visit or contact schools with effective or outstanding programs.
   - Attend conferences, workshops, and other special events that are relevant to the improvement effort.
   - Study successful teaching strategies, review materials and programs, and examine procedures for bringing about program changes.

2. Review all aspects of present program in relation to results in Step 1. See Appendix B; *Science Program Self-Appraisal,* Ohio Department of Education, 1986.

3. Note and describe points of discrepancy between the evaluation criteria (Step 1) and the district's present program (Step 2) to determine changes desired.

   Evaluate these changes against the existing goals and objectives for the science program. Determine what changes are possible and to what extent changes are desired.

4. Write a detailed plan addressing action and resources (personnel and financial) needed to accomplish desired changes.

   - Write a detailed plan of what actions are needed to accomplish desired changes. Include the additional personnel, equipment, resources, and facilities that are essential to implementing the plan.
   - Prioritize the changes.
   - Support proposed changes with background information and implementation strategies.
   - Develop a budget for the required resources necessary to implement the changes. Beyond the need for additional personnel, funds should be considered for textbooks, supplementary materials, inservice programs, conferences, resource materials to supplement both the student and professional libraries, and improvements in equipment and facilities.
   - Designate a representative to lead the improvement process to its conclusion. This individual should have the necessary personnel, financial resources, and long-term backing from the school district.
   - Acquire the support of the board of education.

5. Write a K-12 course of study that includes science philosophy, goals, subject objectives, scope and sequence, evaluation procedures, and board approval statement.

   The Ohio Department of Education booklet, *Process Model for Course of Study*[13] Chapter II, will be very helpful in determining the topics and form of a course of study.

6. Write a K-12 curriculum guide that includes learning activities, teaching strategies, required materials, and equipment.

   - Use the information and planning format from Chapter 6 of *New Dimensions in Science Education* to help develop the curriculum guide and lesson plans for use in the classroom. Give particular emphasis to the four goal clusters of *Project Synthesis.*

   - Arrange for curriculum and materials adoption according to school board policy.

7. Select materials and equipment.

   See *Evaluative Tool for Science Instructional (Print) Materials*, developed by the Inservice Education Science Advisory Council (1986), to develop a useful analysis form that will help determine if the textbook relates to desired objectives and strategies.

8. Conduct administrator and teacher inservice training.

   Provide time and funds for both teachers and administrators to attend inservice activities within the school district and in other locations.

9. Monitor progress to evaluate whether or not changes are taking place by formulating an evaluation plan.

   Develop a strategy for monitoring the plan's implementation process. The monitoring process should include regular meetings throughout the school year to discuss the new program's positive and negative aspects and to develop the means for strengthening identified weaknesses. Monitoring should be ongoing, and difficulties corrected as they develop.

10. Write report on successes, failures, and recommendations for future improvements.

    - Formulate realistic and measurable criteria for determining success. Consider goals, objectives, and skills.

    - Identify baseline data to compare with later measurements to demonstrate changes produced.

    - Monitor the changes throughout the process.

[13] *Process Model for Course of Study*, Chapter II, The Ohio Department of Education, (Columbus, Ohio, 1983).

- Allow for flexibility. A proposed change may not meet the desired objectives. The implementation process should allow for possible adaptations.

- Write a report on the evaluation, with recommendations for distribution to the committee, the administration, and the school board.

Summary

This outline can be modified according to the needs of the district. What is most important, however, is for the district to offer a firm commitment to support the staff during the program evaluation. This commitment should involve having dedicated support staff willing to participate in relevant conferences, or committee efforts, and a budget for preparing final reports. The support of all involved decision makers will make the improvement effort a success.

GOALS FOR ELEMENTARY AND SECONDARY SCIENCE PROGRAMS

Goals help clarify what teachers and students are expected to accomplish. This chapter describes goals to help science program committee members write clear and comprehensive goal statements and to help classroom teachers and school administrators maintain clear expectations for students.

Each school district is required to write a course of study for science, have it approved by the local board of education and the Ohio Department of Education, and maintain the course of study by revising it at least once every five years. The goal statements included in this chapter represent an extensive effort by Ohio educators to distill the main ideas from science curriculum and instruction research into an accessible collection for local school district use. Therefore, the goals listed within this chapter should be used as a guide when writing the lcoal science course of study. As we examine the goals stated on the following pages, realize that local school district conditions may require a different sequence, emphasis, or wording of the stated goals.

A comprehensive science education program's goals are so complex and interrelated that any attempt to divide them into discrete categories is difficult and may be misleading. Numerous schemes have been developed to group similar science program goals. The four goal clusters described in this chapter reflect an emerging consensus of science educators at the national level through *Project Synthesis* (see Chapter 3). The order in which the goals are presented and the number of goals listed does not suggest their relative importance. Yet each must receive serious consideration as the school personnel determine the amount of local emphasis necessary to reflect the district's science program philosophy and program goals.

Variations in each local school district's philosophy, community expectations, and student characteristics may cause different degrees of emphasis for particular goal clusters for different grade levels. The intent is for each goal to be accomplished for all students by the time they exit the science program. It seems improbable that every goal can be addressed in each lesson or unit taught. However, most of the goals listed for each cluster should be accomplished within each grade level or science course in the program. As a result, it is possible for some goals to take on a first level of importance within each lesson or unit, while others assume a second or third level of importance. Also, goal clusters themselves may take on different levels of importance at different grade levels.

Some science teachers may believe that a topic outline is sufficient to direct a science program. This type of belief is usually based on the assumption that student personal growth, societal and technological interrelationships, and career awareness program goals will automatically be developed. Occasionally these desired outcomes may occur, but a planned effort will ensure that these important outcomes receive proper emphasis along with a science prospective.

A balanced comprehensive science education program should include goals representative of the following four goal clusters:

- **Personal development**
- **Societal and technological interrelationships**
- **Academic growth**
- **Career awareness**

The remainder of this chapter describes these goal clusters and appropriate program goals for each.

Personal Development Goal Cluster

The science curriculum must enable students to develop personal qualities in order to cope with an increasingly technological society and to grow as an individual.

This goal cluster focuses on ways to enhance a student's curiosity; honesty; imagination; self-confidence; and ability to be persistent, make decisions, cope with changes, examine values, reason logically, and practice the ethics of science. This goal cluster reflects the many ways science and technology affect one's life. Included are the attitudes and abilities needed to become a successful consumer, to maintain a healthy body, and to use science in making daily decisions and in solving daily problems. Most important is using science to solve personal problems.

Program goals

1.1 The students will understand and use new ideas and scientific information to improve their lives.

1.2 The students will develop skills to support scientific inquiry.

1.3 The students will develop problem-solving skills needed to respond to a changing society and environment.

1.4 The students will develop a positive attitude toward science, that will encourage continued interest and learning.

1.5 The students will develop attitudes and skills to become successful consumers.

Societal and Technological Interrelationships Goal Cluster

The science curriculum must prepare students to function as informed citizens and to deal responsibly with science-related technological issues.

This goal cluster pertains to science-related issues that affect society and technology. Students must have opportunities to develop a greater ability to understand the way science impacts social issues and responsible citizenship, personal interaction with the environment, responsible consumerism, respect for environmental order and aesthetics, and so on.

In addition, this goal cluster enables students to recognize technology and science as worthy human endeavors, to distinguish science from technology, and to understand the impact of each on society's future.

Program goals

2.1 The students will understand the interactions of science, technology, and society.

2.2 The students will recognize that the solution to one problem can create new problems and that decisions made must be relevant to the consequences for other community members.

2.3 The students will recognize that data may be interpreted differently by different people, depending on their values and experiences.

2.4 The students will recognize how the advancement of science and technology has changed the lives of people in local, national, and global communities.

2.5 The students will possess a sense of custodianship (collective responsibility for the environment over a period of time) as the need for conservation increases.

Academic Growth Goal Cluster

The science curriculum must provide all students opportunities to continue lifelong learning to acquire the academic knowledge and skills necessary for solving personal problems. The science program must also provide students who are likely to pursue science and science-related careers with the fundamental knowledge and skills necessary to support further education in their career fields.

This goal concentrates on the knowledge necessary for all students to understand and to become scientifically literate (Chapter 3). The content must include the knowledge, concepts, principles, and ideas of science; the attitudes, values, and ethics of science; and critical-thinking, problem-solving, and psychomotor skills.

Program goals

3.1 The students will develop a knowledge and understanding of scientific principles and concepts.

3.2 The students will develop attitudes, values, and ethics of science to use as a basis for science-related decisions.

3.3 The students will learn to think critically, creatively, and rationally so they can solve problems and promote lifelong learning.

3.4 The students will develop process skills so they can think scientifically. (See Appendix A.)

3.5 The students will develop psychomotor skills so they can manipulate instruments.

Career Awareness Goal Cluster

The science curriculum must enable students to become aware of the utility of science for different occupations and professions.

This goal cluster helps students realize that science is relevant to the world of work. It encourages a positive attitude toward science-related careers and an awareness that these careers provide occupational opportunities for women, minorities, and the handicapped. The many possible careers in science and technology include positions in research, engineering, laboratory technology, equipment design, computer programing, agriculture, nutrition, medicine, santitation, and conservation. Students should learn about contributions that persons in various careers and jobs make to society and about the specific educational preparation, interests, attitudes, and abilities associated with each career. Students must realize that science, mathematics, language arts, and social studies are interrelated and necessary to understand the societal and technological interrelationships.

Program goals

4.1 The students will realize that science and technology are relevant to the world of work.

4.2 The students will develop an awareness of the occupational and professional opportunities in science for women, minorities, and the handicapped.

4.3 The students will develop an awareness of the science education and training requirements for occupations and professions.

4.4 The students will recognize that scientists and technicians possess a full range of personal characteristics and should not be stereotyped. They will recognize the role of the individual; in relation to home, school, community, and the work environment.

4.5 The students will develop effective and positive work habits related to science, employability, and work adjustment.

4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.

Summary

The time spent in selecting or developing clear and concise goal statements is crucial in building a comprehensive science program.

This chapter has introduced some new dimensions for science program goals. The success a school district has implementing these new dimensions may directly relate to the extent that classroom teachers provide consensus and support.

The goals provided in this chapter should be used to clarify science program goals, to develop subject objectives, and to select and develop classroom learning activities. Chapter 7 describes a process for completing this task.

DEVELOPING A SCIENCE CURRICULUM

The function of *New Dimensions in Science Education* to introduce the goal clusters of science education, that are the responsibility of each teacher in the grades K-12 science program. These goal clusters are generally not well-understood, since they have a less direct relationship to the particular topics in the curriculum. In pursuing the suggested goal clusters, it is not so important which topics are taught; it is HOW these topics are taught.

The planning format involves a process that assures that a K-12 science program exists as a continuum of related parts, each associated with a particular grade level or course. The format also assures that each part is organized into discrete subparts, referred to as units or topics of instruction. They should be arranged to provide the continuity of the knowledge, skills and processes, and values within the entire program. Each unit represents a complete course in the basic knowledge of its particular subject. In addition, the format provides a parameter for the unit to provide science instruction, that includes the four goal clusters of *Project Synthesis* and includes classroom activities.

Following the planning format are examples of K-12 development of Physical, Biological, and Earth Science units. THESE ARE ONLY EXAMPLES. Other goals and activities should be developed for a complete, effective K-12 program. These goals and activities should then be used to develop the day-by-day set of plans for teacher use.

Identifying Goals and Activities

The format on the following page is designed to work within the curricula chosen for the particular unit or topic of instruction for a particular grade level. Its completion, by the teacher, using the following steps should provide a science program that assures consistency with the recommendations set forth in *New Dimensions in Science Eudcation.*

The teacher should develop an appreciation of how the goal clusters are realized and implemented to improve students' understanding of all aspects of the started goal clusters.

- Enter the unit title or topic.
- Enter the grade level.
- *Goal Cluster or Program Goals* that can be identified from the *Project Synthesis* model and recommended by The Ohio Department of Education. (See Chapter 6.)
- *Program Goals* are specific teacher-generated strategies, each of which contributes to the continuum of the K-12 science program.
- *Subject Objectives* indicate the specific skills and processes demonstrated by the student on completion of the unit. (See Appendix A.)
- *Activities* contribute to one or more of the particular subject objectives.

Example Format

Planning Format **Topic :** _____ Grade Levels _____

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities

Planning Format **Topic : Physical Science (Kinetic Energy)** **Grade Levels K–3**

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.2 The students will develop skills to define, stimulate, and support scientific inquiry.	The students will be able to understand and recognize the concept of a change in temperature and a change in form.	• *Classifying* materials as specific forms of matter • *Observing* the changes an ice cube makes when exposed to a change in temperature • *Predicting* the manner in which the change can be produced and naming such circumstances found in nature	• Observe an ice cube melting. Feel the ice and then feel the water. Again feel the water after it stands at room temperature. • Examine popcorn before and after popping. Conclude the environment of change. • Place a hot brick in cold water. Observe the changes. • Set a heavy weight on top of an ice cube. Compare the stressed cube as it melts with an ice cube without stress.
2.5 The students will possess a sense of custodianship (collective responsibility for the environment over a period of time) as the need for conservation increases	The students will understand that self-comfort is sometimes at an expense to others.	*Inferring* that materials that provide heat may not be renewable	• Discuss what might happen if gas or oil were not able to be obtained for the purpose of heating. • Discuss what might happen if gas or oil were not able to be obtained for the purpose of transportation. • Collect pictures of common products. Sort according to whether the pictured objects provide energy or use energy.
3.4 The students will develop process skills so they can think scientifically. (Appendix A.)	The students will recognize a relationship between motion and a change in that motion.	*Predicting* methods to change an object's direction of motion	• Identify characteristics of each form of water. • Explore ways to change the direction of a rolling ball. • Blow through soda straws to move Ping-Pong balls or pieces of tissue paper • Design a paper object that will fall slowest among a group of similar objects. Rank objects by the fastest to the slowest to fall.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will recognize the scope and nature of the workplace.	*Inferring* the kind of work done by an individual by *observing* the work environment	• Show pictures of scientists doing research. • Show pictures of nontypical scientists (minorities, women, or handicapped). • Classify the energy source of the scientists' work and identify their contribution to energy usage.

Planning Format **Topic : Physical Science (Kinetic and Potential Energy)** Grade Levels 4-5

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.2 The students will develop skills to define, stimulate, and support scientific inquiry.	The students will recognize that objects in the classroom and home have potential and kinetic energy.	*Describing* and *categorizing* objects in the classroom and home which have potential and kinetic energy.	• Demonstrate potential energy of a bar magnet not aligned with the earth's magnetic field. • Use a bicycle to demonstrate potential and kinetic energy. • Use various toys to classify and demonstrate examples of potential and kinetic energy. • Use a pendulum to illustrate both forms of energy — kinetic or moving and potential or position. • Collect data concerning length of pendulum and number of cycles, graph and interpret data, and draw conclusions.
2.1 The students will understand the interactions of science, technology, and society.	The students will recognize that inventions which use principles of potential and kinetic energy change our lives.	*Identifying* a problem, which involves potential and kinetic energy, *creating an invention* to *solve the problem* and *predicting* how the invention may affect our lives	• Use various common materials to create inventions. • Demonstrate inventions and share predictions. • Examine inventions and modify them to create new ones and new uses. • Develop an operational definition of "science" and of "technology."

3.1 The students will develop a knowledge and understanding of scientific principles and concepts.	The students will be able to recognize that toy manufacturers rely on science and energy principles.	*Generalizing* that a moving object will change its speed or direction only when a force is applied	• Predict the direction of a rolling ball when
			  • an outside force is applied
			  • it collides with another object
			• Analyze the motion of an object swung in a circle.
			• Predict its motion if the string breaks.
			• Use a variable incline to study the effect of gravitational force on a rolling ball.

4.4 The students will recognize that scientists and technicians possess a full range of personal characteristics and should not be sterotyped. Students will recognize the individual's role in relation to home, school, community, and the work environment.	The students will be able to recognize that toy manufacturers rely on science and energy principles.	*Exploring* career opportunities which involve science and energy	• Design a toy that involves energy. • Write a toy company to determine how it might use science or energy in its production of toys.

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.2 The students will develop skills to define, stimulate, and support scientific inquiry.	The students will recognize that the products of science and technology often become controls on individual life-styles.	*Inferring* and *justifying* the need for seat belts, air bags, head restraints, and other safety items in terms of kinetic energy developed by the automobile	• Control and manipulate the variables of mass and velocity, to test the effects of force on toy cars. • Use a specific case of a ball rolling on a flat, level surface to develop a definition of kinetic energy. • Predict stopping distance of different masses. • Design an experiment, collect data, test hypotheses, develop an operational formula for kinetic energy.
2.2 The students will recognize that the solution to one problem can create new problems and that decisions made must be relevant to the consequences for other community members.	The students will realize that the benefits of new products often bring problems in other areas.	*Inferring* and *predicting* the benefits of using light-weight materials for building automobiles and the potential hazards that also result in terms of involvement of kinetic energy	• Compare the physical damage of two model automobiles made of different materials when they collide with a solid object after rolling down an inclined plan. • Develop on operational formula for velocity and speed.
3.3 The students will learn to think critically, creatively, and rationally so they can solve problems and promote lifelong learning.	The students will be able to use numbers and calculate the kinetic energy of an object and its relationship with the mass and velocity of objects.	*Controlling and manipulating* to discover the relationship between mass, velocity, and kinetic energy	• Use qualitative and quantitative observations to describe what happens when a rubber ball is dropped • Use variable inclined planes and automobiles of different masses to calculate and investigate kinetic energy. • Collect and interpret data concerning distance traveled by similar but different objects. Draw conclusions for differences.
4.1 The students will realize that science and technology are relevant to the world of work.	The students will be able to recognize the role that energy plays in occupations.	*Investigating* the principles of the relationship of kinetic energy to traffic accidents	• Interview law enforcement officers to determine the role of kinetic energy in their profession (e.g., formulation of laws, investigations of auto accidents, and safety recommendations to auto manufacturers).

30-A3

30-A4

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.5 The students will develop attitudes and skills to become successful consumers.	The students will recognize and understand that science and technology have made it possible to use unlimited amounts of energy.	*Analyzing* relationships between energy consumption and efficiency of operation	• Describe the difference between predicting and guessing. • Collect data on the cost and energy consumption of refrigerators and analyze the cost to make the best consumer decision. • Design charts and tables to display data. Average measurements to calculate mean values. • Discuss problems that may occur when you only use economic gain as a basis for determining scientific research.
2.4 The students will recognize how the advancement of science and technology has changed the lives of people in local, national, and global communities.	The students will understand the impact of energy usage on wildlife and on the environment and be able to make informed decisions concerning the environment.	*Hypothesizing* about the correlation of populations, change in life-styles, and energy consumption	• Define the standard of living and describe ways it is influenced by science and technology. • Research changes in populations, energy consumption, and living habits over 50 years. Analyze and identify energy consumption trends and the use of resources. Predict future levels of consumption and environmental impacts. • Evaluate the government's right to control the allocation of energy production resources. • Describe ways a citizen can affect energy consumption through the political arena. • Discuss the possibility of unlimited energy due to technology. • Describe changes in home heating and cooling, transportation, and entertainment due to available energy. • Calculate home energy usage.
3.2 The students will develop attitudes, values, and ethics of science to use as a basis for science-related decisions.	The students will understand the relationship between kinetic energy and various properties of matter, (e.g., temperature, energy consumption, and the demands of modern living).	• *Predicting* the effects of temperature and pressure on materials • *Using numbers* to calculate energy changes or usage	• Demonstrate the effect of temperature on the volume of a balloon, or on the pressure inside a container. • Formulate a model for the productive use of waste heat (refrigerant heat). • List ways the students might reduce the energy they consume without sacrificing comfort or satisfaction.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will understand the role of the individual in the home, school, community, and work as it relates to energy consumption.	*Classifying* scientific careers according to their use of kinetic energy	• Identify careers that involve energy in their daily working environment. • Speculate on the direction of energy usage research in the twenty-first century. • Describe changes that have taken place in agricultural careers. • Identify jobs that have been created by technology and jobs that have been destroyed by technology. • Write a job description for an engineer of the twenty-first century. • Research job descriptions that can be identified with high technology.

Planning Format | **Topic : Biological Science (Human Body)** | Grade Levels K-3

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will understand the importance of maintaining a clean body to prevent disease.	• *Communicating* reasons for daily cleaning of the human body • *Inferring* how cleaning the body can reduce disease • *Observing* proper dental care	• Practice washing hands before eating. • Invite a local dentist or dental hygienist to demonstrate proper care. • Collect pictures that demonstrate and display proper procedures. • Discuss cleaning activities.
2.4 The students will recognize how the advancement of science and technology has changed the lives of people in local, national, and global communities.	The students will understand how the lack of cleanliness affects the health of others in the community.	• *Inferring* how communicable diseases, such as common colds, travels from one individual to other individuals • *Observing* proper procedures to clean facilities • *Communicating* the reasons for the proper use of public places and the importance of their cleanliness	• Discuss manners in which diseases are communicated. Infer ways to cut the possibilities of spreading. • Experiment with action of soaps on dirt and oil. Make conclusions as to importance of soap in being clean. • Collect pictures of various cleaning tools and equipment used in the kitchen, the bathroom, and public places.
3.1 The students will develop a knowledge and understanding of scientific principles and concepts.	The students will understand the general framework of the human body and ways it can be kept healthy and strong.	• *Inferring* the function of the human skeleton • *Discussing* ways for caring for and maintaining the human body • *Describing* the functions of basic organs	• Construct a layered model of the human body, including skin, organs and skeletal structure. Allow students to color and display model. • Discuss the skeleton and the organs shown in the model. • Have students or parents communicate their knowledge of having an organ removed, (e.g.,tonsils, appendix). • Discuss the process of healing bones.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will develop an awareness of various professions within the community that relate to the care of the human body.	• *Identifying* major occupations related to health maintenance • *Describing* specific health-care-related services received by individuals in the family	• Construct a collage of different health-care professionals. • Provide hats of health-care costumes for students to wear while they communicate the activities of the professional (e.g., nurse, doctor).

30-B1

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will recognize the role played by the reproduction process in maintaining a population over a period of time.	*Using numbers*, determine the number of children produced in the past three generations within their own family	• Observe, within the classroom, changes during the life cycle of a frog. Compare the time of the frogs life cycle with that of humans. • Illustrate different life cycles (e.g., butterflies, frog, human, salmon) on a bulletin board. • Develop and draw a pedigree tree for the past several generations of one's biological or adoptive families. • Observe and record data as one investigates the development of the chicken, from fertilized egg to hatching.
2.4 The students will recognize how the advancement of science and technology has changed the lives of people in local, national, and global communities.	The students will recognize the changes in society due to the advances made in health care.	• *Collecting data* and graphing life expectancy during the last one-hundred years • *Predicting* the changes that the trend in life expectancy will make in society during the next twenty years	• Debate changes in society that will need to be made to adjust to an aging population. • Develop a map showing the life expectancy in countries of the world. Analyze possible reasons for such results.
3.1 The students will develop a knowledge and understanding of scientific principles and concepts.	• The students will identify the changes that take place in the male and female bodies as they reach maturity. • The students will understand that after reaching a level of maturity—physically, socially, and emotionally, male and female bodies together are responsible for the reproduction process to occur.	• *Describing* the changes that take place in the human body as it approaches sexual maturity • *Communicating* the physical process in human beings, and specifically *identifying* the emotional maturity and the responsibilities necessary for both participants before producing new life	• Discuss changes that occur in the human body during maturity. Describe changes noted in friends and relatives during the past few years. • List different ways that one's parents have cared for them in the past and continue to care for them, and what care will be provided in the future.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	• The students will identify the scientists and their discoveries that changed the quality of life. • The students need to be knowledgeable about genetic research for future decisions concerning careers.	*Making conclusions* concerning the quality of life as changed by certain scientists' work	• Identify accomplishments of scientists, such as Salk and Lister and discuss changes in the student's life-style, had these scientists not done their research and made their discoveries. • Predict future directions of research in the health-care and genetic arenas.

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will recognize the importance of proper nutrition to the functioning of their own body.	• *Identifying* classes of nutrients • *Describing* the function of the nutrients within the body • *Practicing* good nutrition	• Construct a chart that illustrates nutrient classes and body requirements. Test foods for nutrient chemicals (starch, sugar, fats). • Construct a chart of recommended daily allowances (RDA) for different individuals (infants, children, males, females, older adults, pregnant and lactating women). • Recognize symptoms of eating disorders, such as anorexia, bulimia, and lanugo. • List suggestions for providing an adequate diet with economic constraints. • Interpret nutrition information contained on various packages.
2.4 The students will recognize how the advancement of science and technology has changed the lives of people in local, national, and global communities.	The students will recognize the changes in the human community produced by better nutrition.	• *Identifying* changes in food sources due to technology • *Categorizing* food according to nutrients and body needs	• Draw a bar graph that represents life expectancy in the United States over the last twenty years, construct a similar graph for the world, and draw comparisons and conclusions from the two graphs. • Construct a chart of nutrients within common foods. • List food additives within common foods. • Plan a weekly diet for a vegetarian.
The students will develop attitudes, values, and ethics of science to use as a basis for science-related decisions.	The students will understand the function of the digestive system in maintaining a healthy body.	• *Describing* the structures of the digestive system • *Identifying* functions of structures and glands of the digestive system • *Classifying* digestive processes as chemical or mechanical	• Dissect an animal to observe structures and glands of the digestive system. • Demonstrate the food value of one calorie in heat content. • Test for chemical action during chewing. • Test foods for chemical content of nutrients (starch, fats, sugars). • List glands of the digestive system and identify their functions. • Compare various glands and predict the results of loss of their use.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will develop an awareness of various professions within the community related to the food industry.	• *Identifying* careers related to nutrition • *Inventorying* professional activities of individuals related to food production, food storage, and preparation	• Invite a hospital nutritionist to speak to students. • Construct a "career board" to highlight careers related to the food industry.

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will recognize the relationship of heredity to an individual's development.	• *Discussing* problems that exist in studying human genetics • *Explaining* how environment can affect inherited traits • *Naming and describing* sex-linked traits present in animals, including humans	• Conduct a formal debate on the effects of heredity and the environment of humans. • Research studies of identical twins and draw conclusions relating to current information. • Develop a pedigree for a historical figure determined to have a sex-linked trait (e.g., hemophilia). • Construct a pedigree for a specific trait related to the family of an individual.
2.1 The students will understand the interactions of science, technology, and society. 2.2 The students will recognize that the solution to one problem can create new problems and that decisions made must be relevant to the consequences for other community members.	The students will recognize the impact of technology of genetic studies, applied genetics, and genetic engineering.	• *Describing* the process of cloning used currently • *Hypothesizing* on future adaptations and problems this process might cause related to current societal structures • *Naming* synthetic proteins and *discussing* their impact on the quality of life • *Identifying* changes produced by genetic engineering processes	• Design an experiment that would produce a clone of an organism which might lead to a new breed of animal. • Collect data and produce a list of synthetically produced proteins and their effect on life processes. • Compile examples of genetic applications and engineering from newspapers or scientific magazines into a class scrapbook. Compare examples from five years ago to current examples.
3.3 The students will learn to think critically, creatively, and rationally so they can solve problems and promote lifelong learning.	The students will understand the basic Mendelian principles and the concept of continuity of species and populations.	• *Constructing* a Punnett square to show the probable genotypes of offspring • *Collecting and analyzing* data related to genetics • *Describing* the process of meiosis and its impact on the genetic code	• Diagram examples of monohybrid, dihybrid, and trihybrid crosses. • Develop a mathematical relationship between the number of characteristics and the number of possible combinations. • Program a computer to produce statistical information concerning school-wide gene frequencies, such as eye color or Phenylthiocarbamide tasting. • Using visible models of chromosomes, manipulate models to describe meiosis.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will be aware of contributions that persons in the genetic studies field make to society.	• *Explaining* the function of a genetic counselor • *Preparing* a list of questions concerning genetic engineering in plant biology	• Compile a list of genetic defects that a genetic counselor would be able to predict based on a family's medical history. • Vist a college or university botany laboratory and discuss derived questions with a genetic engineer.

Planning Format

Topic : Earth Science (Water-Forms)

Grade Levels K-3

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will be able to recognize that water exists in various forms.	*Identifying* and *describing* forms in which water exists	• Relate experience with rain, snow, and ice and how they relate to one's life. • Use ice, liquid water, and steam from a tea kettle to illustrate three various forms of water. Observe properties of gas, liquids, and solid. • Draw pictures of the forms of water in the environment as ice, snow, rain, or fog. • Group materials that are similar in form to the forms of water.
2.2 The students will recognize that the solution to one problem can create new problems and that decisions made must be relevant to the consequence for other community members.	The students will recognize the use of water in their everyday lives.	• *Identifying* sources of water • *Observing* sources of water • *Inferring* the need for cleaning and purifying the water for use in the community	• Discuss sources of water in the community. • Locate pictures of water sources and produce a collage using the pictures. • Trace the water flow from outside the school through the plumbing to the classrooms, restrooms, and kitchen. • Compare the flow through the school to flow through the home. • Wash hands in basin and relate differences in water before and after its use. • List ways that the students can attempt to reduce water pollution and conserve water. • Examine the effects of pollution on running water using glasses of mud and oil.
3.4 The students will develop process skills so they can think scientifically (Appendix A).	The students will develop the concept that water can be quantified.	*Measuring* the different forms of water	• Collect precipitation in a container. Measure its volume, mass, and depth. • Use weather predictions to predict rainfall for the next day. • Develop a way to measure the volume and mass of ice. • Discuss a way to measure the volume and mass of steam. • Compare the volume of an ice cube with its volume when melted.
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will recognize that there are professionals that deal with water.	*Identifying* professionals that deal with water	• Define "meteorologist" and discuss what knowledge is needed for the position. • Name professionals who are involved with water from rainfall or snowfall to the arrival at the ocean. • Invite the janitor to relate the tools he uses in connection with water flow in the school or the home. • Manipulate simple materials to construct plumbing equipment, such as faucets, pipes, and toilets.

30-C1

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will recognize and be able to describe the water cycle.	*Identifying* and *describing* the various components of the water cycle	• Explain why frost or dew forms on the inside of windows in a home. Discuss the economic aspects of continued action. • Trace the path of water through its entire cycle. • Define and give examples of "components" of the water cycle. • List everyday examples of condensation (e.g., vapor trail, cold drink glass) • Demonstrate the evaporation of alcohol on the blackboard. • Determine the classroom's dew point. • Demonstrate cloud formation by saturated water.
2.4 The students will recognize how the advancement of science and technology has changed the lives of people in local, national, and global communities.	• The students will recognize that the water cycle affects the economic and social characteristics of a region. • The student will recognize that humankind can in some ways alter the water cycle.	• *Identifying* economic and social characteristics of a region as related to the water cycle • *Describing* how cloud seeding can alter the water cycle in a particular locality	• Describe the myths concerning rain production and infer three reasons for their existence. • Observe a demonstration on cloud-seeding. • Design a procedure to produce rain in an area of drought in Africa and predict the economic and social impacts that a change in the water cycle would have on a particular locality.
3.1 The students will develop a knowledge and understanding of scientific principles and concepts.	The students will understand the processes involved in the water cycle.	*Analyzing* the water cycle and its effects	• Record rainfall data for a locality. • Graph rainfall over a period of time and make conclusions for yearly averages. • Calculate amount of rainwater that could be collected from a football field. Calculate the average water per student and compare the results with published results. • Formulate models that would demonstrate steps of the water cycle. (e.g., a shallow pan of water and steps to evaporation, a glass of ice water and steps to condensation)
4.6 The students will become informed of the contributions that persons in various scientific careers and jobs make to society.	The students will recognize that there are occupational opportunities associated with the water cycle.	*Discussing* specific occupations concerned with the water cycle	• List professionals who are involved with water during one cycle. • Identify skills and knowledge needed for the profession. • Identify professions involved with the water cycle that could be performed by handicapped individuals.

Planning Format **Topic : Earth Science (Effects of Running Water)** Grade Levels 6-8

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.3 The students will develop problem-solving skills needed to respond to a changing society and environment.	The students will develop coping skills to deal with problems caused by running water.	*Making decisions* that formulate a plan to counteract the efforts of erosion caused by running water	• Compare aerial photos and topographical maps of local areas. Locate evidence of the effect of climatic and environmental forces of different landscapes. • Communicate via role-playing in which the students determine whether a contractor should be required to terrace the land being developed. • Trace runoff from school grounds to a major river. • Calculate the holding ability of different rocks (e.g., shale, sandstone). List the rocks in order of increasing holding ability.
2.5 The students will possess a sense of custodianship (collective responsibility for the environment over a period of time) as the need for conservation increases.	The students will develop a sense of societal responsibility for conserving natural resources.	*Identifying* the need for conservation of the earth's surface	• Identify and list real problems the students have seen in the community that relate to erosion caused by running water. • Assess real examples of erosion and evaluate the cost to society to continue these practices. • Generalize why local gorges or ravines were formed. • Describe problems that result if pollutants arrive at the underground water source.
3.4 The students will develop process skills so they can think scientifically (Appendix A).	The students will develop the process skills necessary for understanding the effects of running water.	*Predicting* the effects of running water on a particular situation	• Predict effects of excess rainfall on a barren hillside. • Formulate a model that will measure runoff of barren verses vegetated surface area. • Experiment with sand mixtures to determine factors that affect erosion and to predict ways to reduce erosion. • Use measurements from experiment with a model to obtain data concerning transportation of earth materials. • Graph data received and draw conclusions.
4.1 The students will realize that science and technology are relevant to the world of work.	The students will become aware of professional opportunities for preventing erosion by running water.	*Comparing* erosion data required by a farmer to that of a city planner who determines appropriateness for new construction sites	• Contrast the data required and the impact of decisions presented through a panel of students role-playing careers related to soil erosion. • Describe a hydrologist's activities.

30-C4

Goal Cluster or Program Goals	Program Objectives	Subject Objectives	Activities
1.1 The students will understand and use new ideas and scientific information to improve their lives.	The students will develop personal qualities to enhance scientific inquiry.	Using *data collecting* and persistence to study glacial movement	• Gather data from glacial-movement monitoring stations on a regular basis throughout the school year. • Speculate on past changes that have affected glaciers and on how changes that may occur in the future may affect them.
2.2 The students will recognize that the solution to one problem can create new problems and that decisions made must be relevant to the consequences for other community members.	The students will develop a social consciousness.	*Evaluating* information necessary in *making decisions* affecting others in the community	• Participate in role-playing activity (e.g., board game) that explores alternatives for productive land use in the glacial moraine. • Investigate the procedure taken to save the glacial grooves on Kelley's Island.
3.4 The students will develop process skills so they can think scientifically (Appendix A).	The students will develop a general knowledge of glaciers.	• *Communicating* how glaciers are formed,and how they move over the land; *identifying* formations as a result of these changes • *Making models* of the land formations formed as a result of glacial movement	• Construct a model of a glacier using frozen sand and ice. Demonstrate land forms that result. Locate forms on a topographical map. • Study and evaluate theories of the ice age. • View aerial photos of Ohio to identify the impact of glaciers on Ohio's topography. • Estimate and then calculate the percentage of Ohio that has been altered by glaciers.
4.3 The students will develop an awareness of the science education and training requirements for occupations and professions.	The students will develop an awareness of the science requirements necessary to become a glaciologist.	*Investigating* the academic prerequisites necessary to become a glaciologist	• Write to the American and Canadian Departments of the Interior for information about careers in glaciology. • Consult local colleges or universities for similar information.

SUMMARY AND CHALLENGE

Improving science education is an important task that cannot be left to chance. The Ohio Minimum Standards for Elementary and Secondary Schools provide a clear direction for requiring science in all elementary grades K-8. In secondary grades 9-12, each student must take science for at least one year. This is a major commitment of time and resources on the part of our schools and of Ohio citizens. School administrators and teachers have a responsibility for offering a science program that embodies the highest standards in the field and yet is feasible within the school's unique circumstances.

Traditionally, at the high school level, science has been regarded as a subject for the select individuals who exhibit a high level of academic achievement. But this view cannot be accepted due to the minimum standards specified above and due to the need to provide a basic education for all Ohio students. The goal of science instruction at all levels is to develop scientifically literate future citizens, and then to provide further specialized training for those who desire it.

The science curriculum must incorporate the goals of personal development, societal and technological interrelationships, and career awareness in addition to academic growth.

Science for academic growth is a worthy goal and has customarily been emphasized in schools. But the goal of scientific literacy will remain unfulfilled unless the other three dimensions described above also receive sufficient emphasis in the science curriculum.

To provide a high-quality science program for all students, school district personnel must continuously examine the nature of the science content taught, the teaching practices used, and student learning outcomes. A sound strategy for improving the science program consists of systematically studying its development each year, promptly making changes, and conducting a complete program review at least every five years. Even so, a comprehensive science-program monitoring strategy will mean little unless attention is given to science teachers' ongoing staff development.

Developing a science program containing all elements is a critical task. The recommendations address enhancing the educational process by helping students use critical-thinking and problem-solving skills incorporated with new developments and technologies. The fourfold goal cluster serves both research and practice. Experiencing these "new dimensions in science education" will provide students with the knowledge and skills necessary to meet the challenges of the future.

SCIENTIFIC THINKING AND PROCESS SKILLS

1.	OBSERVING*	The most basic process of science, in which students use the senses to obtain information about themselves or the world around them.
2.	QUESTIONING*	To raise an uncertainty, doubt, or unsettled issue that may be based on the perception of a discrepancy between what is observed and what is known by the questioner.
3.	CLASSIFYING	A systematic procedure used by a person to impose order on collections of objects or events.
4.	MEASURING*	A procedure by which one uses an instrument to estimate a quantitative value associated with some characteristic of an object or an event.
5.	USING SPACE OR TIME RELATIONSHIPS*	The description of spatial relationships and their change with time.
6.	USING NUMBERS*	The technique of using numbers to express ideas, observations, relationships, often as a complement to the use of words.
7.	GRAPHING	The technique of representing the variables for comparison in a visual diagram.
8.	RECORDING DATA	Collecting information in an organized fashion about objects and events that illustrate a specific situation.
9.	MAKING ASSUMPTIONS	The process of accepting previously known information as true for forming the basis for testing a hypothesis.
10.	PREDICTING*	Projections of what future observations will be on the basis of previously known information.
11.	FORMULATING MODELS*	Devising a scheme or structure that will describe specific real objects or events.
12.	INFERRING*	Explaining an observation in terms of one's previous experience.

13. HYPOTHESIZING*	Stating a tentative generalization to explain a relatively large number of events, which is subject to immediate or eventual testing by one or more experiments.
14. CONTROLLING VARIABLES*	Identifying and managing the factors that may influence a situation or event so that the effect of one factor may be learned.
15. EXPERIMENTING	Performing a series of data-gathering operations that will test a hypothesis or answer a question.
16. ANALYZING	The process of determining the nature and relationship of the parts of the whole. In an experiment it is the process by which one establishes the relationship between controlled factors and the outcome.
17. REDUCING EXPERMENTAL ERROR	The technique of determining the most valid procedures and process for effective experimentation.
18. INTERPRETING DATA*	Finding a pattern inherent in a collection of data. This process leads to stating a generalization or drawing conclusions.
19. MAKING CONCLUSIONS	The process of inferring a reasoned judgment using collected data.
20. EVALUATING	The technique of examining and judging data presented.
21. GENERALIZING	Drawing a general conclusion from the observations available.
22. DEFINING OPERATIONALLY*	Producing definitions of a thing or event in terms that give it a physical description.
23. COMMUNICATING	Any one of several procedures involving various media which transfer information from one person to another.

* Showalter, V.; Cox, D.; Holobinko, P.; Thompson, B. and Oriedo, M. *What is Unified Science Education? (Part 5) PROGRAM OBJECTIVES AND SCIENTIFIC LITERACY, Prism II*, volume 2, (1974).

SCIENCE PROGRAM SELF-APPRAISAL

Assessment is often defined as a one-time appraisal of achievement and needs of the measured program. This definition is limited if it does not also imply a response to the measurement. Assessment is a continuous process, and measurement is the first step. It must be followed with evaluation, action, and further assessment to determine progress.

Thus, this Science Program Self-Appraisal does not end with the Comparison Chart. In fact, that is only the beginning. You must establish specific goals, plan to attain them, work to achieve them and again evaluate what has been accomplished.

The following checklist is designed for teachers, curriculum designers, principals, and others involved in the science program assessment, design, and development.

CIRCLE THE NUMBER WHICH INDICATES THE EXTENT TO WHICH YOUR SCIENCE EDUCATION PROGRAM FULFILLS THE STATED QUESTION.

I. SCHOOL-LEVEL PLANNING

Possible Score: 20 Self-Appraisal Score: _____

Do you...

1. Develop a philosophy that contains realistic, attainable goals and objectives based on community and pupil needs?

NONE	LOW			HIGH
0	1	2	3	4

2. State a philosophy specifically for science programs and provide it to all staff members who teach science?

NONE	LOW			HIGH
0	1	2	3	4

3. Discuss and explain the philosophy in science staff meetings?

NONE	LOW			HIGH
0	1	2	3	4

4. Use classroom teaching practices that reflect your district's science philosophy?

NONE	LOW			HIGH
0	1	2	3	4

5. Involve teachers in developing and implementing the plan?

NONE	LOW			HIGH
0	1	2	3	4

II. ORGANIZATION AND ADMINISTRATION

Possible Score: 44 Self-Appraisal Score:_____

To what extent does (do) the...

1. Graded course of study meet state recommendations for revision?

NONE	LOW			HIGH
0	1	2	3	4

2. Science curriculum guide clearly document the science program's content?

NONE	LOW			HIGH
0	1	2	3	4

3. Administrator ensure that all students receive instruction in the basic content areas of science?

NONE	LOW			HIGH
0	1	2	3	4

4. Administrator ensure that science instruction is appropriate for student development and learner needs?

NONE	LOW			HIGH
0	1	2	3	4

5. Teachers ensure that science is an integral part of the curriculum?

NONE	LOW			HIGH
0	1	2	3	4

6. Administration hold regular meetings with staff members to discuss the curriculum sequence and to make modifications?

NONE	LOW			HIGH
0	1	2	3	4

7. Science scope and sequence provide an opportunity for all high school students to enroll in at least one science course each year?

NONE	LOW			HIGH
0	1	2	3	4

8. Science program provide for science-related activities that are organized outside the regular weekly schedule (e.g.,science fairs, science clubs)?

NONE	LOW			HIGH
0	1	2	3	4

9. Administration and school scheduling ensure that teachers carry out cooperative planning at each grade level and across grade levels for the teaching of science?

NONE	LOW			HIGH
0	1	2	3	4

10. Administration and science chairperson procure special assistance from outside sources to enrich the science program?

NONE	LOW			HIGH
0	1	2	3	4

11. Administration provide support for implementing, revising, and enhancing the science program?

NONE	LOW			HIGH
0	1	2	3	4

III. PROFESSIONAL DEVELOPMENT: STAFF DEVELOPMENT AND INSERVICE EDUCATION

Possible Score: 36 Self-Appraisal Score: _____

To what extent does the district or school . . .

1. Ensure that teachers responsible for science teaching have properly validated certificates for the assigned courses?

NONE	LOW			HIGH
0	1	2	3	4

2. Ensure that teachers responsible for science teaching have developed the necessary skills for science teaching?

NONE	LOW			HIGH
0	1	2	3	4

3. Provide regular science inservice programs in accordance with the identified needs?

NONE	LOW			HIGH
0	1	2	3	4

4. Provide continuous professional development programs based on a needs assessment?

NONE	LOW			HIGH
0	1	2	3	4

5. Provide a science resource person to assist teachers?

NONE	LOW			HIGH
0	1	2	3	4

6. Provide inservice education programs that offer teachers time to develop specific skills, teaching techniques, and materials that are immediately useful for science teaching?

NONE	LOW			HIGH
0	1	2	3	4

7. Continue a staff development program over an extended period of time and allow for training, skill development, classroom observation, additional follow-up, and teacher coaching?

NONE	LOW			HIGH
0	1	2	3	4

8. Establish and maintain a professional library with science materials and journals so that teachers are able to stay abreast of developments in science teaching and in the respective science fields?

NONE	LOW			HIGH
0	1	2	3	4

9. Encourage and provide release time and financial support for teachers to participate in professional science organizations, meetings, and conferences?

NONE	LOW			HIGH
0	1	2	3	4

IV. SCHOOL AND COMMUNITY

Possible Score: 36 Self-Appraisal Score: _____

To what extent does the district or school provide a science program that realistically serves the student population relevant to...

1. Socio-economic status?

NONE	LOW			HIGH
0	1	2	3	4

2. Ethnic differences?

NONE	LOW			HIGH
0	1	2	3	4

3. Student and community interests?

NONE	LOW			HIGH
0	1	2	3	4

4. Professional expectations within the community?

NONE	LOW			HIGH
0	1	2	3	4

To what extent does the district or school . . .

5. Provide an atmosphere in which students participate freely in discussion of science-related activities and topics, often expressing detailed descriptions of their observations and ideas?

NONE	LOW			HIGH
0	1	2	3	4

6. Ensure that children who are minorities, including females, have opportunities to succeed in the science program?

NONE	LOW			HIGH
0	1	2	3	4

7. Ensure that children who are physically or educationally disabled have opportunities to succeed in the science program?

NONE	LOW			HIGH
0	1	2	3	4

8. Provide opportunities for pupils to do individualized or specialized work in science (e.g., self-paced study, independent study, individual projects, and peer-grouping)?

NONE	LOW			HIGH
0	1	2	3	4

9. Provide appropriate forms of instruction that are recommended by science education research?

NONE	LOW			HIGH
0	1	2	3	4

V. CURRICULUM GOALS AND OBJECTIVES

This section contains five parts. Goal clusters from "Project Synthesis" represent the first four parts: (A) Personal Development, (B) Societal and Technological Interrelationships, (C) Academic Growth, and (D) Career Awareness. Part 5 (E) includes (1) Scientific Thinking and Process Skills, (2) Scientific Attitudes and Values, and (3) Psychomotor Skills — all of which are necessary for an effective science program.

A. Personal Development

Possible Score: 64 Self-Appraisal Score: _____

To what extent does the science curriculum assist students in developing their . . .

1. Physical growth and fitness?

NONE	LOW			HIGH
0	1	2	3	4

2. Emotional development?

NONE	LOW			HIGH
0	1	2	3	4

3. Intellect?

NONE	LOW			HIGH
0	1	2	3	4

4. Social skills?

NONE	LOW			HIGH
0	1	2	3	4

To what extent does the curriculum help students develop a global perspective of concept, such as . . .

5. World citizenship?

NONE	LOW			HIGH
0	1	2	3	4

6. Critical realities?

NONE	LOW			HIGH
0	1	2	3	4

7. Environmental ethics?

NONE	LOW			HIGH
0	1	2	3	4

8. Finiteness of resources?

NONE	LOW			HIGH
0	1	2	3	4

To what extent does the science curriculum help students develop the following behaviors or characteristics...

9. Self-fulfillment?

NONE	LOW			HIGH
0	1	2	3	4

10. Flexibility?

NONE	LOW			HIGH
0	1	2	3	4

11. Resourcefulness?

NONE	LOW			HIGH
0	1	2	3	4

12. Responsibility?

NONE	LOW			HIGH
0	1	2	3	4

13. Creativity?

NONE	LOW			HIGH
0	1	2	3	4

14. Cooperativeness?

NONE	LOW			HIGH
0	1	2	3	4

15. Work-leisure balance?

NONE	LOW			HIGH
0	1	2	3	4

16. Ability to cope with changes?

NONE	LOW			HIGH
0	1	2	3	4

B. Societal and Technological Interrelationships

Possible Score: 20 Self-Appraisal Score: _____

To what extent does the science curriculum. . .

17. Enable students to identify the local, national, and global impact of scientific discovery and technological development?

NONE	LOW			HIGH
0	1	2	3	4

18. Provide students with decision-making skills that will enable them to make responsible decisions?

NONE	LOW			HIGH
0	1	2	3	4

19. Provide students with opportunities to evaluate a decision in terms of values and consequences?

NONE	LOW			HIGH
0	1	2	3	4

20. Encourage students to apply science in their daily lives?

NONE	LOW			HIGH
0	1	2	3	4

21. Enable students to develop scientific ethics as they relate to society?

NONE	LOW			HIGH
0	1	2	3	4

C. Academic Growth

Possible Score: 20 Self-Appraisal Score: _____

To what extent does the science curriculum. . .

22. Enable students to learn scientific concepts?

NONE	LOW			HIGH
0	1	2	3	4

23. Enable students to learn concepts that emphasize the interdisciplinary nature of science?

NONE	LOW			HIGH
0	1	2	3	4

24. Enable students to learn concepts that emphasize technological and social issues?

NONE	LOW			HIGH
0	1	2	3	4

25. Enable students to be aware of and understand the history and philosophy of science?

NONE	LOW			HIGH
0	1	2	3	4

26. Enable students to understand the nature of scientific inquiry?

NONE	LOW			HIGH
0	1	2	3	4

D. Career Awareness

Possible Score: 20 Self-Appraisal Score: _____

To what extent does the science curriculum . . .

27. Ensure that students are aware of scientific and technological requirements of entry-level and professional science-oriented careers that are open to all individuals, including females, minorities, and handicapped individuals.

NONE	LOW			HIGH
0	1	2	3	4

28. Provide students at all grade levels with opportunites to interact with science-related professionals, both in the school and on job sites?

NONE	LOW			HIGH
0	1	2	3	4

To what extent does the science curriculum provide career counseling opportunities, which include . . .

29. Assessment of personal strengths and limitations?

NONE	LOW			HIGH
0	1	2	3	4

30. Employment opportunites and trends in careers that use science?

NONE	LOW			HIGH
0	1	2	3	4

31. Assistance in career decisions?

NONE	LOW			HIGH
0	1	2	3	4

E. Scientific Skill Development

1. Scientific Thinking and Process Skills

Possible Score: 96 Self-Appraisal Score: _____

To what extent does the science program enable students to develop and use the following intellectual thinking skills and scientific process skills . . .

32. Observing?

NONE	LOW			HIGH
0	1	2	3	4

33. Questioning?

NONE	LOW			HIGH
0	1	2	3	4

34. Classifying?

NONE	LOW			HIGH
0	1	2	3	4

35. Measuring?

NONE	LOW			HIGH
0	1	2	3	4

36. Using space and time relations?

NONE	LOW			HIGH
0	1	2	3	4

37. Using numbers?

NONE	LOW			HIGH
0	1	2	3	4

38. Graphing?

NONE	LOW			HIGH
0	1	2	3	4

39. Recording data?

NONE	LOW			HIGH
0	1	2	3	4

40. Making Assumptions?

NONE	LOW			HIGH
0	1	2	3	4

41. Predicting?

NONE	LOW			HIGH
0	1	2	3	4

42. Formulating?

NONE	LOW			HIGH
0	1	2	3	4

43. Inferring?

NONE	LOW			HIGH
0	1	2	3	4

44. Hypothesizing?

NONE	LOW			HIGH
0	1	2	3	4

45. Controlling Variables?

NONE	LOW			HIGH
0	1	2	3	4

46. Experimenting?

NONE	LOW			HIGH
0	1	2	3	4

47. Analyzing?

NONE	LOW			HIGH
0	1	2	3	4

48. Reducing experimental error?

NONE	LOW			HIGH
0	1	2	3	4

49. Interpreting data?

NONE	LOW			HIGH
0	1	2	3	4

50. Making conclusions?

NONE	LOW			HIGH
0	1	2	3	4

51. Evaluating?

NONE	LOW			HIGH
0	1	2	3	4

52. Generalizing?

NONE	LOW			HIGH
0	1	2	3	4

53. Defining operationally?

NONE	LOW			HIGH
0	1	2	3	4

54. Communicating?

NONE	LOW			HIGH
0	1	2	3	4

2. Scientific Attitudes and Values

Possible Score: 56 Self-Appraisal Score: _____

To what extent does the science program enable students to develop the following scientific attitudes and values . . .

55. Curiosity?

NONE	LOW			HIGH
0	1	2	3	4

56. Humility?

NONE	LOW			HIGH
0	1	2	3	4

57. Skepticism?

NONE	LOW			HIGH
0	1	2	3	4

58. Open-mindedness?

NONE	LOW			HIGH
0	1	2	3	4

59. Avoidance of dogmatism or gullibility?

NONE	LOW			HIGH
0	1	2	3	4

60. Positive approach to failure?

NONE	LOW			HIGH
0	1	2	3	4

61. Objectivity?

NONE	LOW			HIGH
0	1	2	3	4

62. Longing to know or understand?

NONE	LOW			HI
0	1	2	3	4

63. Questioning of all things?

NONE	LOW			HIGH
0	1	2	3	4

64. Search for data and their meaning?

NONE	LOW			HIGH
0	1	2	3	4

65. Demand for verification?

NONE	LOW			HIGH
0	1	2	3	4

66. Respect for logic?

NONE	LOW			HIGH
0	1	2	3	4

67. Consideration of premises?

NONE	LOW			HIGH
0	1	2	3	4

68. Consideration of consequences?

NONE	LOW			HIGH
0	1	2	3	4

3. Psychomotor Skills

Possible Score: 60 Self-Appraisal Score: _____

To what extent does the science program enable students to develop psychomotor skills required for manipulating instruments? (The following list does not include all instruments and equipment. It represents examples, and they may be applicable to specific courses only.)

69. Microscope?

NONE	LOW			HIGH
0	1	2	3	4

70. Thermometer?

NONE	LOW			HIGH
0	1	2	3	4

71. Meter stick?

NONE	LOW			HIGH
0	1	2	3	4

72. Balance?

NONE	LOW			HIGH
0	1	2	3	4

73. Graduated cylinder?

NONE	LOW			HIGH
0	1	2	3	4

74. Timing device?

NONE	LOW			HIGH
0	1	2	3	4

75. Bunsen burner?

NONE	LOW			HIGH
0	1	2	3	4

76. Calculator?

NONE	LOW			HIGH
0	1	2	3	4

77. Tape recorder?

NONE	LOW			HIGH
0	1	2	3	4

78. Microcomputer or computer terminal?

NONE	LOW			HIGH
0	1	2	3	4

79. Sphygmomanometer?

NONE	LOW			HIGH
0	1	2	3	4

80. Oscilloscope?

NONE	LOW			HIGH
0	1	2	3	4

81. Instruments that record data as a function of time?

NONE	LOW			HIGH
0	1	2	3	4

82. Ammeter?

NONE	LOW			HIGH
0	1	2	3	4

83. Computer interfacing?

NONE	LOW			HIGH
0	1	2	3	4

VI. CURRICULUM AND COURSE CONTENT

Possible Score: 32 Self-Appraisal Score: _____

To what extent does the science curriculum and the course content . . .

1. Provide a meaningful and logical scope and sequence for science teaching?

NONE	LOW			HIGH
0	1	2	3	4

2. Provide for specific subject objectives?

NONE	LOW			HIGH
0	1	2	3	4

3. Provide for a balance of instruction in physical, biological and earth science?

NONE	LOW			HIGH
0	1	2	3	4

4. Require a laboratory or hands-on activity centered classroom environment for all grades?

NONE	LOW			HIGH
0	1	2	3	4

5. Provide an opportunity for students to use science process skills regularly?

NONE	LOW			HIGH
0	1	2	3	4

6. Emphasize problem-solving and the development of intellectual skills?

NONE	LOW			HIGH
0	1	2	3	4

7. Emphasize the development of scientific attitudes and values?

NONE	LOW			HIGH
0	1	2	3	4

8. Emphasize the development of psychomotor skills by using manipulative scientific instruments?

NONE	LOW			HIGH
0	1	2	3	4

VII. INSTRUCTION AND TEACHING METHODS

Possible Score: 56 Self-Appraisal Score: _____

To what extent does your science program. . .

1. Require science to be taught regularly at each grade level?

NONE	LOW			HIGH
0	1	2	3	4

2. Provide for a teacher-pupil ratio that does not exceed 1 to 24 in any science class?

NONE	LOW			HIGH
0	1	2	3	4

3. Encourage teachers to use various instructional methods, including discussion, group experiments, modeling, multimedia presentations, individual investigation or research, and student tutoring and questioning?

NONE	LOW			HIGH
0	1	2	3	4

4. Provide for instruction that gives students frequent opportunities to apply science to their lives and in their relationship to society?

NONE	LOW			HIGH
0	1	2	3	4

5. Provide students opportunities to resolve problems through cooperative efforts?

NONE	LOW			HIGH
0	1	2	3	4

6. Encourage students to broaden their view of science by placing importance on the multiple dimensions of science?

NONE	LOW			HIGH
0	1	2	3	4

7. Extend the study of science outside the classroom to include field trips to locations such as science and technology centers, museums and other public institutions as well as industry, land labs, nature preserves, etc.?

NONE	LOW			HIGH
0	1	2	3	4

8. Use multiple evaluation techniques in all science classes to test progress toward goals and objectives and for identifying strengths and weaknesses rather than for "grade keeping" or use as punishment?

NONE	LOW			HIGH
0	1	2	3	4

9. Include laboratory and hands-on materials in conjunction with written materials?

NONE	LOW			HIGH
0	1	2	3	4

10. Encourage teachers to modify lessons when appropriate to account for students' needs and interests?

NONE	LOW			HIGH
0	1	2	3	4

11. Encourage science teachers to work with teachers of other subjects to integrate student learning, e.g., integrate science into non-science subject areas and vice versa?

NONE	LOW			HIGH
0	1	2	3	4

12. Incorporate current events or happenings into science oriented activities?

NONE	LOW			HIGH
0	1	2	3	4

13. Provide students opportunities to learn about new research discoveries occurring in business and industry?

NONE	LOW			HIGH
0	1	2	3	4

14. Provide frequent communication with parents concerning standards expected in science courses?

NONE	LOW			HIGH
0	1	2	3	4

VIII. INSTRUCTIONAL MATERIALS AND RESOURCES, AND SCHOOL FACILITIES

Possible Score: 44 Self-Appraisal Score: _____

To what extent does the science program...

1. Ensure that science teachers are involved in selecting and purchasing quality materials, textbooks, supplemental resources, supplies and equipment?

NONE	LOW			HIGH
0	1	2	3	4

2. Ensure that teachers participate in inventorying, ordering, storing, and safely using science materials?

NONE	LOW			HIGH
0	1	2	3	4

3. Ensure that safe practices are used in science classes?

NONE	LOW			HIGH
0	1	2	3	4

4. Provide proper facilities within the building to keep and care for live animals?

NONE	LOW			HIGH
0	1	2	3	4

5. Provide classrooms with facilities for audiovisual presentations, scientific demonstrations, and hands-on experiments?

NONE	LOW			HIGH
0	1	2	3	4

6. Provide classrooms with running water, sinks, electrical outlets, and other laboratory equipment suitable for program needs?

NONE	LOW			HIGH
0	1	2	3	4

7. Provide adequate, secure, and safe storage space for equipment and supplies?

NONE	LOW			HIGH
0	1	2	3	4

8. Provide science materials (e.g., thermometers, measurement equipment, seeds, and aquaria) in sufficient quantities to enable all students to experience hands-on activities?

NONE	LOW			HIGH
0	1	2	3	4

9. Provide a reliable, adequate budget to purchase needed equipment and to provide ongoing maintenance and repairs?

NONE	LOW			HIGH
0	1	2	3	4

10. Ensure that the media center or library includes a collection of science-oriented books for all grades and student ability levels?

NONE	LOW			HIGH
0	1	2	3	4

11. Ensure that laboratories and activities are accessible to handicapped students?

NONE	LOW			HIGH
0	1	2	3	4

IX. EVALUATION

Possible score: 48 Self-Appraisal Score: _____

To what extent does the science program...

1. Delineate the science facts, concepts, thinking skills, process skills, and psychomotor skills to be mastered by students at each grade level?

NONE	LOW			HIGH
0	1	2	3	4

2. Encourage teachers to base pupil evaluations on the science program's goals and objectives?

NONE	LOW			HIGH
0	1	2	3	4

3. Encourage teachers to develop specific evaluation policies regarding the optimum frequency of tests?

NONE	LOW			HIGH
0	1	2	3	4

4. Encourage teachers to use a wide range of evaluation techniques?

NONE	LOW			HIGH
0	1	2	3	4

5. Encourage teachers to develop and use special grading criteria for students who exhibit unique strengths or weaknesses?

NONE	LOW			HIGH
0	1	2	3	4

6. Encourage teachers to use objective and subjective forms of evaluation?

NONE	LOW			HIGH
0	1	2	3	4

7. Encourage parents to visit science classrooms?

NONE	LOW			HIGH
0	1	2	3	4

8. Require that regular parent-teacher conferences are scheduled?

NONE	LOW			HIGH
0	1	2	3	4

9. Require a planned, systematic evaluation of the science program?

NONE	LOW			HIGH
0	1	2	3	4

10. Use a program evaluation that is based on science program goals and objectives?

NONE	LOW			HIGH
0	1	2	3	4

11. Require program evaluation that includes teacher, pupil, and parent feedback?

NONE	LOW			HIGH
0	1	2	3	4

12. Have revisions based on the results of a systematic evaluation?

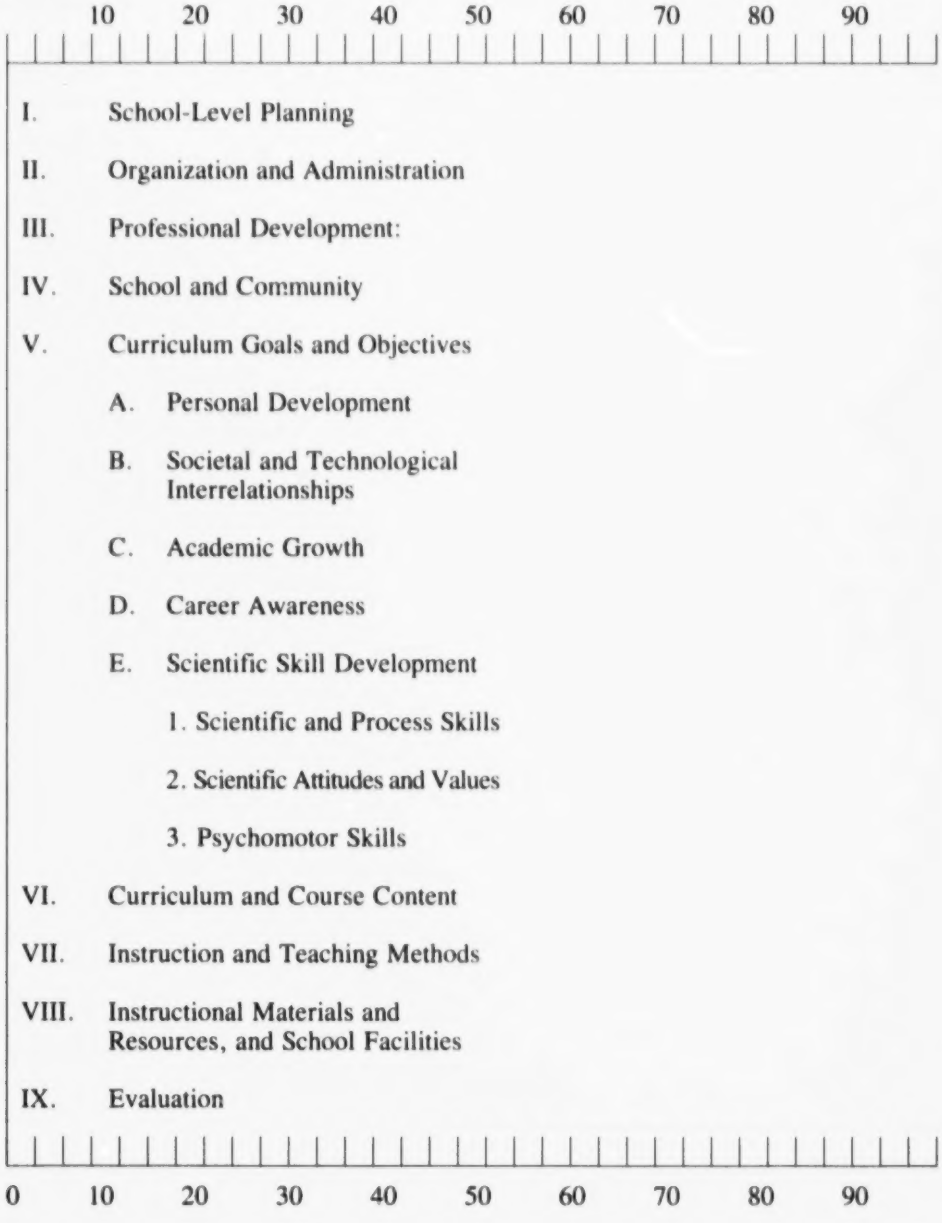
NONE	LOW			HIGH
0	1	2	3	4

SUMMARY OF SELF-APPRAISAL SCORES

		Possible Score	Self-Appraisal Score	% Score
I.	School-Level Planning	20		
II.	Organization and Administration	44		
III.	Professional Development: Staff Development and Inservice Education	36		
IV.	School and Community	36		
V.	Curriculum Goals and Objectives			
	A. Personal Development	64		
	B. Societal and Technological Interrelationships	20		
	C. Academic Growth	20		
	D. Career Awareness	20		
	E. Scientific Skill Development	96		
	1. Scientific and Process Skills	92		
	2. Scientific Attitudes and Values	56		
	3. Psychomotor Skills	60		
VI.	Curriculum and Course Content	32		
VII.	Instruction and Teaching Methods	56		
VIII.	Instructional Materials and Resources, and School Facilities	44		
IX.	Evaluation			
	Total Score	744		

SCORE COMPARISON CHART

Chart your *self-appraisal percentage scores* to determine strong and weak areas of your science program.


10 20 30 40 50 60 70 80 90
I. School-Level Planning
II. Organization and Administration
III. Professional Development:
IV. School and Community
V. Curriculum Goals and Objectives
A. Personal Development
B. Societal and Technological Interrelationships
C. Academic Growth
D. Career Awareness
E. Scientific Skill Development
1. Scientific and Process Skills
2. Scientific Attitudes and Values
3. Psychomotor Skills
VI. Curriculum and Course Content
VII. Instruction and Teaching Methods
VIII. Instructional Materials and Resources, and School Facilities
IX. Evaluation
0 10 20 30 40 50 60 70 80 90

SCIENCE PROGRAM SELF-APPRAISAL SUMMARY

1. Overall, the science program rates:

2. Strengths evident in the science program include:

3. Program areas most in need of improvement include:

4. Short-range goals for improving the science program include:

5. Long-range goals for improving the science program include:

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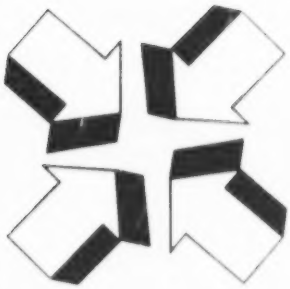

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